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DISEASES OF LETTUCE

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CIRCULAR 448

DISEASES

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J U N E

1 9 5 5



Healthy

This plant and the one at right are of the same age and the same variety (Great Lakes).

OF LETTUCE

The control of lettuce diseases is particularly important in California, where growers produce almost two-thirds of the United States crop, where every month lettuce goes to market from one or more areas, and where most of the country's lettuce seed is grown.

Lettuce diseases have a great variety of causes, and methods for prevention or control vary with each disease. Therefore it is of the utmost importance to identify diseases correctly and to know when and where they are likely to occur. It is equally important to know what to do and what *not* to do.

This circular is designed to aid in the recognition of the important diseases of lettuce in California. Color photographs and descriptions treat the distinctive features of each disease, their area and seasonal distribution, and the effect of climate on their occurrence and severity. Control methods, insofar as known, are described at the end of each section.

Diseased

Note stunting, yellowing, and rolling of leaves, caused by common lettuce mosaic.



LETTUCE MOSAIC...

is caused by a virus that is carried by seed and spread by aphids. The disease is found in practically all lettuce regions and can ruin a crop by its mottling, stunting, and other effects. Prevention is the only control.

Common lettuce mosaic, often referred to simply as mosaic, has been reported from many lettuce areas of the world since it was first recognized as a virus disease and described in Florida in 1921.

Mosaic is one of the major diseases of lettuce (*Lactuca sativa* L.) in California. It is found in all of the commercial growing acreage of the state. It damages lettuce by causing yield reduction and loss of quality.

Symptoms differ in young, old plants

Young plants first show a slight inward rolling along the long axis of the leaf. When the plant's first true leaves appear, they are often irregular and slightly lobed. These symptoms are followed or accompanied by light-green-to-yellow mottling. In the young rosette stage infected plants may show vein clearing and bronzing. The latter symptom is due to brown flecking of the leaf blade, especially along the smaller veinlets.

In older plants the mottle symptom usually disappears or becomes indistinct, and other symptoms must be relied upon for recognition of the disease. Half-grown to mature plants infected with mosaic are usually severely stunted and show a discoloration that varies from a dull green to a slight yellow. Tips of outer leaves roll downward, and the plants appear somewhat wilted even though actually they are not. Any mottling that is distinguishable can best be seen near the margins of leaves.

Most mosaic-infected plants, especially those that become infected early, are con-

spicuously stunted. If you cut such a stunted plant at ground level and turn it over, you will often see distinctly protruding petioles (leafstalks) giving the underside of the head a ribby appearance. This symptom is especially evident in the Great Lakes variety.

In seed plants mosaic is easily recognized as a yellow-green mottle in the younger leaves of infected plants that have bolted.

Symptoms vary according to the variety that is infected. The symptoms described above (for older and younger plants) are typical of lettuce mosaic in most crisphead varieties. Certain varieties, however, are more sensitive to the virus. Imperial D and Eiffel Tower Cos, for example, develop mild-to-severe necrosis (tissue death) of the leaf blade. Occasionally Great Lakes and Imperial 615 plants, besides showing the usual mottling, stunting, and rolling of leaves, become necrotic in a manner similar to the typical Imperial D reaction. In such instances mosaic is often difficult to distinguish from the early symptoms of spotted wilt.

Virus introduced by seed transmission

The lettuce mosaic virus is seed-borne, and this is the principal way in which the virus is introduced into lettuce plantings. It has been found to a greater or less degree in all commercial seed lots that have been tested. The percentage of seed transmission is low, usually about 1 to 3 per cent, but may exceed 6 per cent. At a seeding rate of 1½ pounds per acre, a 1 per cent transmission rate

would, on the average, produce one mosaic-infected seedling in each four feet of bed before thinning.

Several wild hosts—for example, *Lactuca serriola* (wild lettuce)—are susceptible to common lettuce mosaic virus and may serve as sources of the virus. However, seed-borne infected lettuce plants, scattered within the field, remain the principle source.

Aphids spread virus in the field

Several species of aphids are the sole agents responsible for spreading the lettuce mosaic virus after it has been seed-borne into the field. Usually symptoms appear 10 to 15 days after the aphids have transmitted the virus to healthy plants.

The amount of mosaic in a field largely depends on the size and movement of the aphid population, since the rate of introduction by seed varies only between 1 and 3 per cent. In early spring and sometimes late fall, when aphids are normally quite abundant, much more mosaic appears in the field than in summer plantings when aphids are generally scarcer.

Although it is possible to transmit mosaic mechanically by rubbing juice of infected plants on leaves of healthy plants that have been sprinkled with a mild abrasive, there is little danger that any

cultural operations will spread the virus.

However, any cultural practice that dislodges aphids from diseased plants and permits them to move to healthy plants may markedly increase the local spread of mosaic. For example, don't remove a diseased plant from a field without first killing any aphids that may be present. Otherwise the aphids may leave that plant and carry the virus to a new one.

Best control is prevention

There is no cure for mosaic after a plant has become infected. Effective control of lettuce mosaic by controlling the insect vectors (the aphids) has not been demonstrated. However, if insecticides are applied in an attempt to control the insect vectors, they should be applied just before any cultural operation—such as thinning—that would disturb the vectors and cause movement from diseased to healthy plants.

Resistance to mosaic has not been developed, so far, in any variety or strain of commercial head lettuce. Paris Island Cos is more tolerant than other Cos varieties.

Mosaic-free seed has been produced by a combination of isolation, insect control, and roguing. Extensive experimental tests have shown that this seed offers an effective means of controlling mosaic.

Mosaic-infected leaf from Imperial D variety shows necrosis (dying) of leaf.

Leaf from Imperial 615 variety shows mottle reaction to mosaic.



ASTER YELLOWS...

is a virus disease spread by leafhoppers. It is not usually serious in California lettuce, except in seed crops. No control method is known.

This virus disease, first described on China asters, is also known by the more or less descriptive terms "white heart" and "rabbit's ear." Another name is "Rio Grande disease" because it was first recognized as a serious trouble of lettuce in the Rio Grande Valley of Texas.

There are at least two strains of the aster yellows virus—the Eastern and the Western, named for their geographical distribution in the United States. The Eastern strain causes a serious disease of lettuce but does not attack celery. The Western strain, on the other hand, seriously damages celery but does not usually cause extensive losses in lettuce. This is the type that is common in California.

Blanching, chlorosis are first symptoms

The first symptoms of aster yellows are blanching and chlorosis (lack of chlorophyll) in the young heart leaves. Center leaves fail to develop normally and may appear as short, thickened stubs in the center of the affected plant. Pink-to-tan latex deposits collect on the affected leaves.

In head lettuce similar deposits are sometimes found deep inside mature heads that were infected too late to show external symptoms of the disease. These pink-to-tan deposits from ruptured latex vessels give an objectionable appearance to the interior of the head. In general,

infected plants are stunted, fail to "head," and are worthless for market.

In lettuce seed plants that have bolted, aster yellows induces an abnormal development of dormant buds in the leaf axils (the points where leaves join stems), and bushy outgrowths result. Flower buds are also distorted and produce little or no viable seed.

Susceptible plants are source of virus

The aster yellows virus is not seed- or soil-borne. It lives over winter in susceptible weeds and cultivated plants, both biennial and perennial, and is spread to other susceptible plants by leafhoppers.

Only one species of leafhopper is known to transmit the Eastern strain of the virus. The Western strain is transmitted by several species.

The virus cannot be spread to healthy plants by any known mechanical means except grafting. There is therefore no danger of spreading it by cultural practices in the field.

No satisfactory control method is known

So far no control method has been found that is satisfactory. In the East, all varieties of lettuce studied have been equally susceptible. In California the disease isn't usually prevalent enough in lettuce to warrant attempts at control.



Pink latex deposits on interior leaves of this mature head resulted from a late infection of aster yellows. Few if any external symptoms of late infections can be detected.

THE COVER PHOTO...

... also illustrates aster yellows effects. Yellowing, stunting, leaf distortion, and failure to head are typical results of an early infection of this virus disease.

SPOTTED WILT...

*is a world-wide virus disease, very damaging to lettuce.
Thrips spread the virus. No effective control exists.*

This widely-distributed virus disease has been reported from several States and from many foreign countries. In California spotted wilt is most serious in coastal areas, where it sometimes causes wide-spread destruction of lettuce and other susceptible crops. It attacks lettuce plants in all stages of growth.

Variety of symptoms can be seen

Spotted wilt is characterized by a wide variety of symptoms.

Young plants turn yellow, flatten out, and die; these symptoms are somewhat similar to those of Sclerotinia rot. The two diseases are easily distinguished,

however, since spotted wilt does not have the white, fluffy fungus growth or the sclerotia associated with Sclerotinia rot.

On older plants, the disease is characterized by marginal wilting, yellowing and necrotic spotting of the leaves and midribs. One side of the plant is usually affected more than the other. This one-sided attack may cause an unequal growth, resulting in a decided curvature of the petioles of diseased leaves. Dead brown streaks and pits are usually evident along the under side of the midrib of affected leaves. The younger heart leaves may have numerous small brown dead spots, or the whole heart may die and turn black. Plants affected by the

Spotted wilt virus causes one-sided browning and yellowing of leaves and necrotic pitting of the midrib.



spotted wilt virus are liable to attack by several rot-producing organisms. Bacterial slime, which frequently follows other troubles, often abounds in fields where spotted wilt damage is prevalent.

Virus attacks many cultivated crops

The spotted wilt virus attacks many cultivated crops, such as tomato, celery, eggplant, and bell pepper. It spends the winter on certain weeds and many ornamentals, some of which are perennial, such as calla lily, nasturtium, dahlia, and chrysanthemum. Spotted wilt infection is usually greater in lettuce fields near urban areas, where these perennial ornamentals abound.

Virus spread in the field by thrips

The virus causing spotted wilt is spread by several species of thrips which have fed on infected plants while in the nymph

stage. It is not spread by aphids or other insects. The thrips become infective about nine days after feeding and remain so the rest of their lives. About 15 days after susceptible plants have been inoculated, symptoms appear. This incubation period may be slightly shorter or considerably longer—sometimes as long as 30 days.

The virus can be transmitted by rubbing healthy plants with infective juice combined with a mild abrasive, but no spread results from handling of plants or from other cultural practices. The virus is not seedborne.

No effective control has been found

No effective control of this disease is known. Attempts at control of the disease by control of the insect vector (thrips) have given unsatisfactory results.

All commercial head lettuce varieties are susceptible, although the Mignonette variety escapes infection in the field.

Close-up view shows necrotic pitting of midribs and necrosis of smaller veins, again due to spotted wilt.



BIG VEIN...

is a soil-borne disease of unknown cause. Its effects are less serious than other diseases of lettuce. A measure of control is possible through soil fumigation and proper choice of soil.

First reported from Imperial Valley in 1934, big vein has since been found in other California areas, on the East Coast, in Bermuda, and in New Zealand. It is not as damaging as some other lettuce disorders, since affected plants may produce marketable heads. If plants are affected early, size and quality of heads may be reduced and maturity delayed.

Leaf area around veins becomes translucent

Plants infested with big vein usually assume a decidedly upright habit of growth, instead of curving outward in the normal way. Veins of infected leaves turn a pale yellow and begin to clear; as they become clearer the leaves pucker slightly, giving the margins a ruffled appearance. Finally the area around the veins becomes translucent, causing the veins to appear enlarged.

Actual cause is unknown

Big vein is caused by a soil-borne agent, usually considered to be a virus, although definite proof is lacking. The agent has been reported to remain in the soil, in an infective state, for as long as eight years. Experimentally it has been destroyed by soil treatments such as steaming, formaldehyde drenching, and chloropicrin fumigation.

Seeking a possible vector of the disease, investigators have tested aphids and nematodes, with no success except for one questionable instance of transmission by the root aphid *Prociphilus betae* (Doane).

Whatever the causal agent may be, experiments have shown that it is confined to the roots and soil. Successful inoculations have been made by adding juice from infected plant roots to the soil around healthy plants, but inoculations with juice extracted from the tops of diseased plants failed to cause infection. Furthermore, it has been found impossible to inoculate healthy plants by rubbing their leaves with infective juice from roots if the juice is prevented from contacting the soil near the root zone of the healthy plant.

Wet soil, cool weather favor big vein

Big vein is more common in wet, heavy soils. Symptoms are most evident when air temperatures are cool—i.e., between 42 and 60 degrees;* symptoms develop at soil temperatures ranging from 62 to 83 degrees.

Avoid infested soil in cooler seasons

Experimentally, incidence of big vein has been decreased through soil fumigation with chloropicrin or DD (dichloropropene-dichloropropane mixture) or CBP-55 (chlorobromopropene). More work needs to be done before recommendations for field application can be made.

About the only practical measure that can be taken against big vein is to avoid infested soil during the cooler seasons when the disease is likely to be most severe.

* All temperatures Fahrenheit.



View of whole plant shows severe vein clearing and ruffling of leaves peculiar to big vein.

Individual leaf (below) illustrates severe vein clearing, a characteristic symptom of big vein.



SCLEROTINIA ROT...

is a widespread fungus disease that does most damage to maturing lettuce in over-watered fields during moist, cool weather. No control method has been adequately tested for California conditions.

This fungus disease, also known as *drop*, occurs in most lettuce-growing areas. It may attack a crop at any stage of growth when cool and moist conditions prevail. The disease is most prevalent, however, in the later stages of plant development.

Wilting leaves are first symptoms

The causal fungus organism, *Sclerotinia sclerotiorum*, invades the main stem at or near ground level. Lower leaves wilt and collapse first. Finally, as the fungus rots through the stem, the whole plant wilts and dies. Leaves turn yellow, and the entire plant appears flattened and limp.

In advanced stages a soft, watery, brown rot severs the stem from the root. Under moist conditions the white, cottony growth of the fungus may be found on the undersides of leaves and on the stem. Eventually this growth produces the hard, black bodies—known as sclerotia—that enable the fungus to persist in the soil in the absence of a susceptible crop.

Fungus attacks wide range of plants

Sclerotinia attacks a wide range of plants; the more susceptible ones include clover, celery, beans, and several members of the cabbage family. Relatively non-susceptible crops suited to culture on infested land include sugar beets, spinach, and the cereals. Although cropping the land with a non-susceptible plant

prevents the build-up of sclerotia, a short rotation of this kind is usually ineffective as a control.

The fungus produces irregularly-shaped, dark-brown-to-black sclerotia varying in size from $\frac{1}{16}$ to $\frac{1}{2}$ inch in diameter. From these sclerotia saucer-shaped spore-bearing structures arise on stalks during wet periods. Although these structures, called apothecia, release ascospores into the air, they are of little or no importance in the infection of lettuce. It is the resumption of vegetative growth by sclerotia close to a lettuce plant that generally accounts for infection. The fungus usually starts to grow on senescent or dead leaves beneath the plant and progresses in to the crown where it causes a rot at the soil surface.

Another fungus, *Botrytis cinerea*, may also enter the plant at the crown by way of dead or injured leaves. Once having gained entrance the fungus may cause a complete rotting of the crown, resulting in wilt, yellowing, and collapse identical with the drop caused by Sclerotinia. These two fungus rots can be distinguished easily, however, because Botrytis produces abundant masses of greyish-brown spores on the surface of the rotted tissues, whereas Sclerotinia produces no such spores, but only white mycelium and black sclerotial bodies.

No way found to rid land of sclerotia

No completely satisfactory way of eliminating sclerotia from infested land has yet been found. Partial control of

the disease has been reported to result from applications of cyanamid—sometimes as much as a thousand pounds per acre—and from land flooding for long periods during the summer. Neither of these methods has been adequately tested in California.

Sclerotinia rot is usually prevalent in fields that have been overwatered but is rare in fields that have been irrigated properly. Particular care should be taken to keep the tops of beds as dry as possible after plants are almost mature.



Top: plant shows wilting and dropping of leaves caused by a fungus, *Sclerotinia*, which has attacked the crown.



Center: Close-up view of rotted crown reveals abundant white mycelium and black sclerotia of *Sclerotinia*.



Bottom: An example of crown and root rot caused by the *Botrytis* fungus. Note grayish-brown spore masses on the surface of the rotten tissue.

DOWNY MILDEW...

is a fungus disease common in most lettuce localities where weather is cool and moist. Its leafspotting, which provides entry for rot-inducing organisms, can be serious. Control with fungicides is possible.

This common lettuce disease, caused by the fungus *Bremia lactucae*, has been reported from most localities where lettuce is grown. It can cause considerable damage, especially to early spring and late fall crops in coastal areas. It is favored by cool, moist weather, and therefore occurs rarely in Imperial Valley—only when there is an unusual amount of rain or dew.

Outside leaves severely affected by the fungus must be trimmed off before packing for shipment. Other crop losses may occur in the field or in transit to market by the invasion of secondary slime and rot-producing organisms. These organisms gain entrance through tissues injured by the downy mildew fungus.

First symptoms are pale green spots

The first symptoms of mildew are pale-green-to-yellow spots, usually angular, which appear on the upper side of affected leaves. These spots may enlarge and join together to affect large areas of the leaf. On the lower side of the spots appears a white, fluffy fungus growth which produces abundant spores capable of infecting other leaves. Under favorable conditions the white fungus growth and sporulation may occur over both upper and lower surfaces of the lesions, especially in the young seedling stage prior to or at the time of thinning.

Fungus is spread by windborne spores

The spores of downy mildew fungus which serve to spread the organism from one field or to another are rather short-

lived but may survive for several days after being detached. They are windborne and can be carried for considerable distances. The fungus usually does not survive in the soil for very long periods and is rarely, if ever, seedborne. Most primary infection must therefore come from current crops. This mode of survival is common in areas where a succession of overlapping lettuce crops are grown.

Climatic conditions have an important effect on downy mildew. Spore production and lettuce infection are greatest when the air temperature is about 50 to 60 degrees and the air has been saturated with moisture for five to seven hours. Rain, heavy dew, or fog can provide such saturation.

Varieties resistant to one or more strains

Several varieties are resistant to one or more strains of down mildew fungus. Jagger used a French variety, Romaine Blonde Lente à Monter, as a source of resistance to produce the varieties Imperial D and F, which, at one time, appeared to be resistant. These varieties are now susceptible, however, because other strains of the fungus have developed or because Imperial D and F have lost their original resistance.

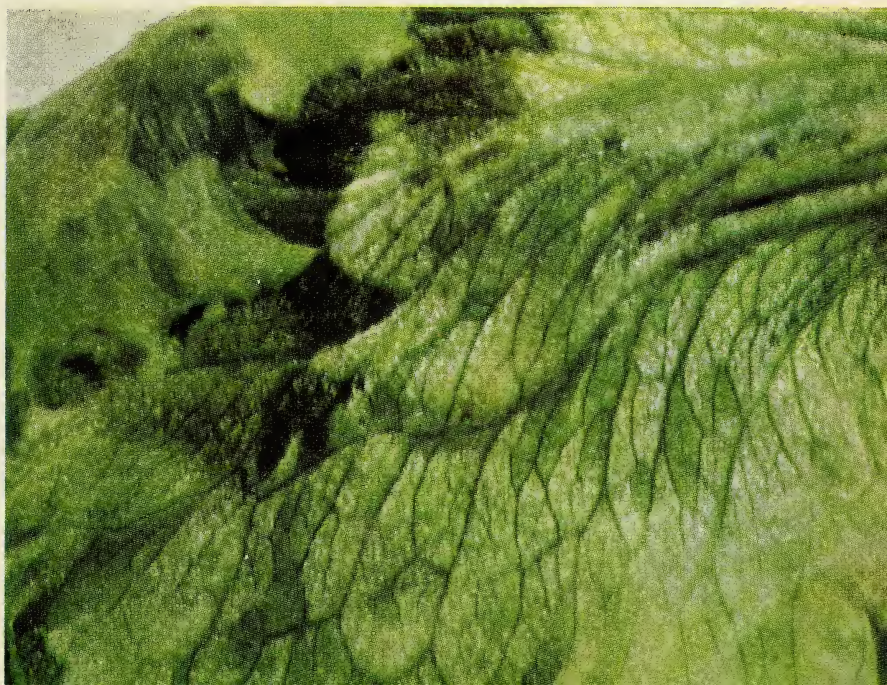
Some control is possible

No varieties are resistant to all strains of the fungus. Spraying or dusting with copper or organic fungicides at frequent intervals has been reported to give some control.



Downy mildew caused the yellowed and dead areas on the outer leaves of this severely-diseased plant.

In this close-up, note the lesions showing white sporulation of the fungus. Lesions tend to be limited by the leaf veins, so that spots often appear angular in shape.



POWDERY MILDEW...

covers the surface of lettuce leaves with a white, powdery fungus growth, reducing yield and quality. It is not generally a serious threat to crops. Sulfur dusting controls the fungus.

First reported in Salinas Valley in 1941, this disease apparently disappeared until 1951, when it was found in the same area. It is not yet widely distributed but seems to be on the increase. It is caused by the fungus *Erysiphe cichoracearum* D.C.

The fungus has many strains, each highly specialized to attack certain crops. So great is this specialization that the strain of powdery mildew fungus which attacks wild lettuce does not infect culti-

vated lettuce. The fungus strain that first appeared in 1941 was probably a mutation from the strain that attacks wild lettuce.

Principal effect is on older, outer leaves

Powdery mildew affects principally the older, outer leaves. The fungus develops on both leaf surfaces, producing an abundance of white, powdery spores and fungus growth; occasionally it pro-

A severe attack of powdery mildew fungus killed large areas of these leaves.





Abundant white sporulation covers upper leaf surface.

duces small, round, black fruiting bodies containing the sexual spore stage of the organism.

Leaves affected by the fungus become slightly yellow and then take on a brown, scorched appearance. A strong odor resembling that of mushrooms is noticeable. Heads infected before reaching marketable size may remain small and poor in quality. Total yield may be reduced.

Don't confuse disease with downy mildew

Because of their similarities, powdery and downy mildew are often confused. They are both fungus diseases. Both produce white accumulations of spores on the foliage.

Several differences, however, exist:

Downy mildew is a wet, cool-weather disease seen most abundantly on early spring plantings during the rainy season and affecting especially the young plants. Infections on older leaves are usually

localized, occur principally on the under surface, and are evident on the upper surface as well-defined, angular, yellow spots or blotches more or less bordered by the leaf veinlets.

Powdery mildew is more apt to occur in fall and is not dependent on wet weather. It occurs mostly on the older leaves, on both leaf surfaces, causing a slight yellowing and browning without a sharp delimitation of infected areas.

Control possible by sulfur dusting

Dusting lettuce with sulfur at first appearance of the disease and at subsequent intervals will control powdery mildew, provided temperatures are high enough to volatilize the sulfur.

Dusting with sulfur will *not* control downy mildew; therefore it is of great importance to determine with certainty which mildew is present before initiating a control program.

ANTHRACNOSE...

is a fungus disease and can cause serious damage, although it is not common in California. Wet, cool conditions favor anthracnose. Effective control can be achieved.

Several other names are applied to this disease, which is caused by the fungus *Marssonina panattoniana* (Berl.) Magn. It is known as shot-hole, leaf perforation, ring-spot, or rust. However, anthracnose is the name most used in the United States.

Although anthracnose is not common in California, the disease has caused severe damage to early spring plantings near Salinas, Sacramento, and Marysville after cool, wet periods in the spring.

Severely-diseased leaf shows brown lesions and shot-hole symptoms of anthracnose.



Shot-holes are characteristic

Small, tan, water-soaked spots appear on the lower leaves of affected plants. These spots usually enlarge slightly, and straw-colored spots $\frac{1}{16}$ inch in diameter or larger develop. Later the centers of these spots fall out, forming characteristic "shot-holes." The leaf looks as though it had been chewed by insects. It withers and dies quickly and may blow away, often leaving a small head on a bare stalk.

Other symptoms appear as numerous, small, watersoaked areas on the underside of the midrib. These areas elongate, darken, and may be slightly sunken. Badly affected midribs may appear rough in contour because of the many sunken lesions. This phase of the disease might be confused with spotted wilt, but the latter does not defoliate or cause the shot-hole symptom in leaf blades and is more prevalent later in the season.

Fungus favored by cool, wet conditions

Abundant moisture is needed for spore production, germination, and penetration of the host plant. Infection can occur at temperatures around 60 degrees, but not at 77 degrees or higher.

Splashing water from rain or overhead irrigation is the most important means by which the fungus spores spread in the field. They can also spread during cultivation if plants are wet with dew or rain. A third means of spread is by wind-blown, infected plant material.

Wild lettuce a source of infection

Probably the most important source of infection under California conditions is wild lettuce (*L. serriola* L.). Anthracnose commonly occurs on wild lettuce during the early spring months.

Although the disease has been reported to survive on seed, it is very unlikely that lettuce seed grown in California during the warm, dry, summer months transmits it; such climatic conditions are quite unfavorable for the development and spread of the fungus.

The fungus can also survive for eight months to a year in plant refuse in the soil.

Three ways to prevent anthracnose

Three practices help prevent the disease: Rotate with nonsusceptible crops for at least a year in fields where the disease has occurred; eliminate wild lettuce in the vicinity of commercial fields; do not work fields when they are wet, since the fungus spreads by contact from plant to plant at such times.

Anthracnose, artificially induced, caused these numerous tan-to-brown lesions on midribs and leaf blades.



STEMPHYLIUM LEAF SPOT...

is a wet-weather fungus disease. It is of occasional importance in the coastal district of central California. Crop sanitation aids in its prevention.

This disease of lettuce is also known as Colma leaf spot because its occurrence in California was first recognized in the Colma (San Mateo County) vegetable-growing area. It is a fungus disease which depends upon wet weather for its appearance and spread.

In the United States the disease seems to be limited largely to the central coastal area of California, but it has also been reported in several foreign countries. It is sometimes serious in San Mateo County truck gardens, where spotting—especially of the leaf lettuce varieties—impairs or destroys marketability of the product.

Symptoms are brown, circular spots

Symptoms of the disease consist of light brown spots on the most exposed outer leaves of the plant. The spots are roughly circular, and under moist conditions they become more or less concentric as they enlarge. Under very wet conditions the spots may coalesce to form large, brown, dead areas, which give affected plants a scorched appearance. Generally the spots are rather evenly distributed on the leaf, indicating that the infection has originated from air-borne spores. Diameters of the spots vary and may be as large as $\frac{1}{4}$ inch. Their uni-

formly brown color and larger size distinguish them from anthracnose.

Two spore forms of fungus start infection

Infection may start from either of two spore forms of the fungus. The sexual stage, known as *Pleospora herbarum* f. *lactucae*, produces spores that are readily wind-borne. The asexual stage—*Stemphylium botryosum* f. *lactucae*—has spores that are principally water-borne. However, both depend on free water or saturated atmospheric conditions for spore germination and infection. The fungus lives through the summer in dead, infected refuse from a previous crop.

Although leaf, cos, and head lettuce varieties are all susceptible, the exposed foliage of leaf lettuces makes them the most vulnerable to damage by stemphylium leaf spot.

Sanitation best way to prevent disease

Disease prevention depends on crop sanitation. Since the fungus persists in infected crop refuse remaining on the surface of the ground, such refuse should be turned under the soil to hasten its decay and to prevent the discharge of spores into the air.

In areas particularly subject to the disease, overhead irrigation should be avoided or reduced to a minimum.



Above: Plant shows severe leaf-spotting after infection by *Stemphylium* leaf spot.



Right: Target-like spots may be as large as $\frac{1}{4}$ inch in diameter. Brown color and larger size distinguish these spots from anthracnose lesions (see page 18).

TIPBURN...

damages lettuce both externally and internally, causing serious crop losses in California. The Great Lakes variety shows some resistance to the disease.

This is a nonparasitic disease which appears to be most prevalent when bright, warm days follow periods of damp, foggy weather. It causes serious losses in all California lettuce areas every year.

Although the occurrence of tipburn is generally accepted as being correlated with high temperature, there is neither proof nor agreement as to what actually causes the disease.

Several factors have been reported to influence the amount and severity of the disease: (1) Rapidly-growing succulent plants tend to be more susceptible than plants that have developed more slowly. (2) High humidity, as well as high temperature, favors occurrence of the trouble. (3) Fluctuating or inadequate soil moisture may increase the amount of tipburn.

With present knowledge it is impossible to judge which of these factors is most important.

Outer leaves were removed from this plant to show leaf and vein necrosis of the interior leaves from tipburn.



First symptoms are dark brown spots

The first symptoms produced by tipburn are small, dark brown spots about $\frac{1}{4}$ inch from the edge of the leaf. The tissue around these spots often dies and turns brown.

Tipburn may also occur internally: necrotic spots and patches of veinlet necrosis near leaf margins may appear throughout the interior of the head. Such dead areas within the head offer excellent places for rot-producing organisms to become established, especially certain bacteria that cause a watery tissue breakdown commonly known as "slime."

Since tipburn is a nonpathogenic disease—i.e., no organism causes it—there is no spread-in-the-field, in the usual sense of the phrase.

Control is through resistance

A certain amount of control is possible through the use of the Great Lakes variety, which is somewhat resistant to tipburn and is widely used in areas at times when tipburn is likely to strike.

But even this variety can develop typical symptoms and in addition may show necrosis of petioles and midveins. This last symptom has been called rib rot, rib blight, or rib discoloration.

For adequate control of tipburn, other varieties must be developed that are more resistant to all phases of the disease.



Tipburn of outside wrapper leaves.

Rib discoloration and broken ribs in Great Lakes variety.



A WARNING ABOUT FERTILIZERS

Fertilizer injury is often overlooked as a lettuce disorder. Nevertheless, it can cause serious damage. Symptoms of this trouble are variable but can be described as follows:

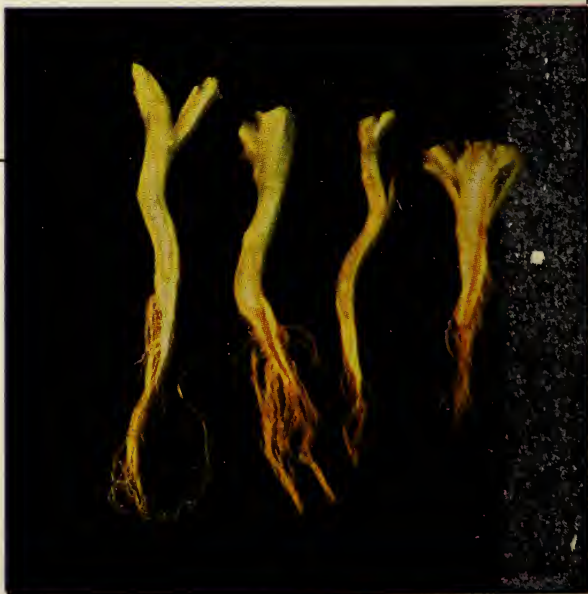
Affected plants wilt temporarily and the leaves become dull green or slightly yellowed. Such plants may recover almost completely or may show various degrees of stunting. The above-ground symptoms are due to damage of the root system. Small rootlets, larger lateral roots and even the tap root may be killed. The most characteristic symptom, however, is a yellow, red, or brown discoloration of the water-conducting tissue in the center of the root. In cases of severe damage the injured water-conducting tissue may collapse, forming a cavity which sometimes extends into the crown. Plants with a badly damaged root systems may die completely.

All of the commonly-used fertilizer materials may cause damage if large amounts of a concentrated form are applied in direct contact with the roots. However, some fertilizer materials are much more toxic than others. The most toxic materials contain free ammonia. Other materials, from which free ammonia or nitrites may be formed as a result of microbial or chemical action in the soil, also can cause similar damage.

To prevent damage, all fertilizers should be used at the lowest effective rate and should be applied so that contact of roots with concentrated materials is avoided.

These precautions are especially important when the more toxic materials are being used.

Roots damaged by excessive application of fertilizer.



OTHER DISEASES...

of lettuce—damping-off, slime, calico, and brown blight—also occur in California but at present are of minor importance.

In addition to the foregoing diseases of lettuce, there are others which, although not necessarily minor in other states or countries, are of little importance in California.

Some of these diseases are mentioned here only briefly—either because they are less well understood or because they present no particular problems. Any of these, however, may come into importance at any time.

Damping-off is a disease of young seedlings. Before or soon after they emerge the plants are attacked by various fungi, such as *Rhizoctonia solani* and *Pythium spp.* Excessively wet and unfavorable growing conditions for seedling growth are conducive to damping-off.

Preventive measures include: treatment of seeds with an appropriate fungicide; choice of favorable planting conditions; and avoidance of land improperly prepared or known to contain a high population of *Rhizoctonia* or other damping-off fungi built up in a preceding crop. Also conducive to damping-off of seedlings are excess salinity or alkalinity (or both) at the soil surface and extremes of temperature.

Slime is the name applied to the breakdown of head lettuce due to a secondary invasion of bacteria and/or fungi, which are usually in the soil and on-or-about healthy plants but which are unable to attack sound, healthy tissues. Injury of tissues opens the way for rapid bacteria and fungus invasion, especially when the injury is accompanied by free water.

Injuries that permit such invasions can

be caused by sunburn, frost, disease, insects, and chemical burn from high salts, fertilizers, or spray materials.

Calico is a virus disease found for the first time in 1953, near Greenfield, Monterey County, California. Its symptoms appear mainly on older and intermediate leaves and range from a diffuse yellow mottle with yellow ring spots to brilliant yellow or white calico-like patterns.

Most plants infected by calico become severely stunted.

Cause of the disease is a tobacco ring-spot virus strain, whose vector is unknown.

Brown blight appeared in the early 1920's soon after the beginning of lettuce culture in Imperial Valley. It was also reported from other parts of California and from Arizona.

This disease may occur on plants from the three- or four-leaf stage up to maturity. First symptoms are small, light, yellow, discolored spots in the leaves. These spots enlarge, and the areas be-

BUY THE BEST SEED

One of the best forms of "insurance" in lettuce growing is to use premium quality seed. Yet many growers try to skimp on seed quality to save a few dollars in production costs.

By putting out a few more dollars per pound for the best seed available, they are likely to save many dollars in the long run by avoiding seedborne diseases, seed mixtures, and poorly-adapted types of lettuce.



Yellow ringspots and yellow-to-white, calico-like pattern, caused by tobacco ring-spot virus, can be seen on the older and intermediate leaves of this calico-infected plant.

tween become yellow-green as the leaves expand. Infected plants are much reduced in size and tend to lie flat on the ground. They turn brown; their leaves die from the base upward. Plants that are attacked after attaining considerable size develop dead brown streaks and blotches on the leaves. Stems or crowns of affected plants are apt to be unusually brittle and are easily broken off at ground level.

The cause of brown blight has not been determined. A disorder with strikingly similar symptoms has been observed recently in certain lettuce varieties growing in highly saline soils of Imperial Valley. The lettuce varieties planted when brown blight was serious may have been more subject to salt damage than modern varieties. These were introduced by the late

Dr. I. C. Jagger, who began his investigations in California in 1922. Since these varieties have come into general use brown blight has not been a serious problem.

June yellows, a term used in the past to denote a general, nondescript yellowing of the spring crop, has come to stand for a disease complex and therefore is not treated here as a separate disease of lettuce. Yellowing of the foliage may be induced by a variety of causes, notably mosaic, but also by faulty nutrition, excessive salinity, poor root development, the use of unsuitable varieties, unfavorable climatic or soil factors, and even certain infectious diseases. Since "June yellows" is not one disease but can be several, the term no longer has real meaning.

ASSISTANCE from many individuals and firms made this circular possible: among these, University colleagues M. W. Gardner, J. B. Kendrick Sr., C. E. Scott, J. E. Welch, and L. D. Doneen; A. A. Tavernetti and P. A. Kantor; Grower-Shipper Vegetable Association, Salinas, Associated Seed Growers, Inc., Dessert Seed Co., Pieters-Wheeler Seed Co., Rohnert Seed Co., Woodruff Seed Co.; and Ferry-Morse Seed Co., whose photographer, Arlyle Grensted, took many of the pictures.

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